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(54) METHOD AND APPARATUS FOR PURIFYING GASES

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No. OF CLAIMS 9

# ABSTRACT


A method and apparatus for purifying gases containing molten and evaporated components and for recovering smelt and possibly heat as well. The hot gases are caused to pass, at a high velocity, through a channel provided with turbulence generating means to which molten particles adhere when impinging against them, thereby being separated from the gases. At the same time the gases are indirectly cooled by a fluid flowing through the turbulence generating means whereby evaporated components condense on their surfaces.

## METHOD AND APPARATUS FOR PURIFYING GASES

Background of the invention

The present invention relates to a method and an apparatus for purifying furnace gases containing molten and evaporated components and for recovering smelt and possibly heat as well.

In many branches of industry there is a need to burn material containing metals, salts and oxides in addition to combustible substances. On one hand the objective of the combustion process is the recovery of the energy thus released, and on the other the recovery of incombustible chemicals. The relative importance of said aspects depends on the application. The primary object of burning spent liquors from pulping processes is usually the recovery of chemicals and the recovery of heat remains a secondary though an important objective. In metallurgical smelting processes the recovery of metal is the primary and the recovery of heat the secondary objective. When burning various process liquors, e.g. waste liquors from alcohol distilleries, the object of the process is to destroy the liquor, but the recovery of heat energy can make the process profitable. However, all these combustion processes generate hot flue gases containing molten components. In addition, incombustible substances such as salts and oxides usually evaporate to a considerable extent.



In the eutectic temperature range molten and evaporated salts and oxides cause severe contamination of the heat-recovering surfaces, therefore the combustion process in modern steam liquor boilers is carried out in a big radiation chamber and the generation of small smelt droplets is avoided. The radiation chambers are made big to ensure a solidification as complete as possible before the convection heat surfaces.

However, big smelt droplets are disadvantageous from the point of view of the combustion process. The ability of the radiation chambers to separate droplets is above all based on the low velocity of the gas which causes the structure to be big and expensive.

Usually the temperature after the radiation chamber of a liquor boiler is very near to the difficult eutectic region and the flue gases still contain a considerable amount of sticky particles. To ensure the availability of the boiler the channels between the heat surfaces following the radiation section are made spacious and they are provided with efficient soot blowers. Also this fact raises the price and operating cost of the boiler.

In the metallurgical industry the combustion chamber is usually followed by a settling chamber for the smelt wherefrom the gases are usually directed into a waste heat boiler. The boiler is usually constructed as a separate unit to which the combustion chamber and the settling chamber are connected by means of a flue gas channel. The settling chamber is rather an inefficient smelt separator, and being uncooled it is totally incapable of removing evaporated components from the gases.

#### Summary of the invention

The principal idea of the method according to the invention is to remove the molten components causing trouble from the gases in a temperature range in which the evaporated salts and oxides have condensed to a great extent on the cooled surfaces of a

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droplet separator but in which the smelt is still in molten form. To achieve said goal the gases are made to pass, at a high velocity, through a channel provided with turbulence generating means. The molten particles which impinge against these means adhere to them thereby being separated from the gas. At the same time the gas is indirectly cooled by a heat exchange fluid flowing through the turbulence generating means, whereby the evaporated components in the gas condense on their surfaces.

The combustion unit comprises a combustion chamber operating in a manner known per se into which the liquor to be burned is fed finely atomized, and a cooled separator designed for efficient separation of smelt and situated immediately after the combustion chamber. The heat transfer capacity of the separator is dimensioned in such a manner that at the exit temperature of the flue gases the smelt is still in molten form but substantially all the evaporated salts have condensed.

The method according to the invention is also applicable as such in metallurgical smelting processes. The advantages gained are: efficient separation of smelt and inexpensive equipment.

The droplet separation is mainly carried out by means of the turbulent movement of the particles which causes the droplets to impinge against the cooled surfaces of the separator. The simplest version of such a separator consists of a group of cooled pipes arranged sufficiently close to each other. The separation of the droplets can be made more efficient by subjecting the gas flow to rapid changes of direction. To achieve adequate turbulence and a sufficient inertia effect the flow velocity of the gas in the separator has to exceed 6 m/sec., e.g. from 10 to 50 m/sec., preferably 20 to 40 m/sec. Boiler water can be used as the coolant in which case part of the heat required for the evaporation in the boiler is obtained from the separator.

Brief description of the drawings

The invention is described in more detail in the following with references to the annexed drawings in which

Fig. 1 is a schematical illustration of an application of the invention in a combustion unit equipped with a heat recovering apparatus;

Fig. 2 shows a sectional view of Fig. 1 along line A-A and

Fig. 3 - 6 show alternative embodiments corresponding to Fig. 2.

Description of the preferred embodiments

In figures 1 and 2, illustrating the combustion unit, numeral 1 indicates a combustion chamber into which the material to be burned is fed through a nozzle 2 and air through an opening 3. The flue gases coming from the combustion chamber are directed into a separator 4 which comprises turbulence generating means forming a number of parallel flow channels 5, which turbulence generating means are formed of pipes 7, 8, 9 and 10, into which a cooling liquid is fed, and of plates 11 connecting pipes 7 and 8, 8 and 9, 9 and 10 to each other. The pipes 8, 9, and 10 in front of the pipes 7, in relation to the flow direction, are situated in such a manner that they form zig-zag-shaped channels, through which the flue gases are made to flow at a high velocity and in which the flow direction repeatedly changes. Thus turbulence is generated in the channels, due to which most of the smelt particles in the flue gases are separated when impinging against the turbulence generating means of the separator and evaporated components are condensed on its cooled surfaces. The pipes form an angle of  $45^{\circ}$  with the horizontal level, therefore the smelt flows along the surfaces of the turbulence generating means onto an inclined surface 12 of the combustion unit and continues towards the deepest sections of a flue gas channel 13 wherefrom it is removed through an opening 14. Thereafter the almost pure flue gases are directed into a heat-recovering apparatus 15, into which the cooling liquid, which has flown through the separator, is fed and in which steam is generated in a manner known per se.

Figures 3 - 6 illustrate alternative embodiments of the sep-

arator. Fig. 3 shows an embodiment in which a guide plate is attached to the pipes 7, 8 9, and 10 in such a manner that the plates 16 attached to the pipes 7 and 9 form an angle with the plates 17 attached to the pipes 8 and 10.

Fig. 4 shows an embodiment in which the turbulence required and the changes in the flow direction of the gases are generated by staggering the pipe rows 7 - 10, on top of one another.

Fig. 5 shows an embodiment in which an angle iron 18 has been attached to the pipes 7 - 10 so that a spout along which the smelt can flow is formed.

In figure 6 the pipes 7 and 9, 8 and 10 have been joined by parallel plates 19 disposed in the flow direction of the gas.

It is evident that the separator can also be made of some other type of turbulence generating means than illustrated in the figure. To enable the smelt to flow along the turbulence generating means, they should form an angle of 10 to 90°, preferably 30 to 60°, with the horizontal level.

The following example presents results gained from an application of the method according to the invention.

#### Example

Spent liquor having a dry substance content of 60 % from a sulphate cellulose plant was combusted in a steam boiler according to Fig. 1. According to analyses the composition of the dry substance was as follows:

C = 0,38

H = 0,04

S = 0,05

Na = 0,19

O<sub>2</sub> = 0,34

The combustion process generated ash from 35 to 40 % of the

amount of dry substance. The combustion was carried out in oxidizing conditions, at an air coefficient ranging from 1,05 to 1,20. The separator used was similar to the one shown in Fig. 4, in which the outer diameter of the pipes was 33 mm, the free passage  $\varnothing$  between the pipes 67 mm, and the flow velocity in the corresponding section 20 m/sec. The average combustion temperature before the separator was  $1070^{\circ}\text{C}$  and after it  $900^{\circ}\text{C}$ . Saturated boiler water having an absolute pressure of 11 bars, was used as the coolant. The cooling capacity of the separator, in the case taken as an example, was 10 to 15 % of the total steam generating capacity. The separating effect calculated on the basis of the sodium content was approximately 88 %, therefore only approximately 12 % of the smelt got to the heat surfaces after the separator. Naturally, even better results are feasible.



The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of purifying gases containing molten and evaporated components and of recovering smelt, wherein the gases are made to pass, at a high velocity, through a channel provided with turbulence generating means to whike<sup>ch</sup> molten particles adhere when impinging against them, thereby being separated from the gases; and that the gases are at the same time indirectly cooled by a heat exchange fluid flowing through said means whereby evaporated components in the gases condense on the surfaces of the turbulence generating means.
2. A method according to claim 1 wherein the flow velocity of the gases in the channel exceeds 6 m/sec.
3. A method according to claim 2, wherein the flow velocity of the gases ranges from 10 to 50 m/sec., preferably 20 to 40 m/sec.
4. A method according to claim 1, wherein the gases are subjected to repeated changes of the flow direction created with the help of turbulence generating means.
5. A method according to claim 4, wherein the flow direction change is about 90°.
6. An apparatus for purifying gases containing molten and evaporated components and for recovering smelt, comprising a channel for directing said gases to flow in a predetermined direction, in which channel there are several adjacent cooling pipes situtated in levels one above the other and extending at an angle relative to the horizontal level and generally transversely in relation to said direction.
7. An apparatus according to claim 6, wherein the pipes for<sup>m</sup> an angle of 10 to 90° with the horizontal level.
8. An apparatus according to claim 6, wherein the pipes on top of one another are staggered and joined together with plates so that they form several parallel flow channels.
9. An apparatus according to claim 6, wherein spout-forming plates are attached to the cooling pipes.



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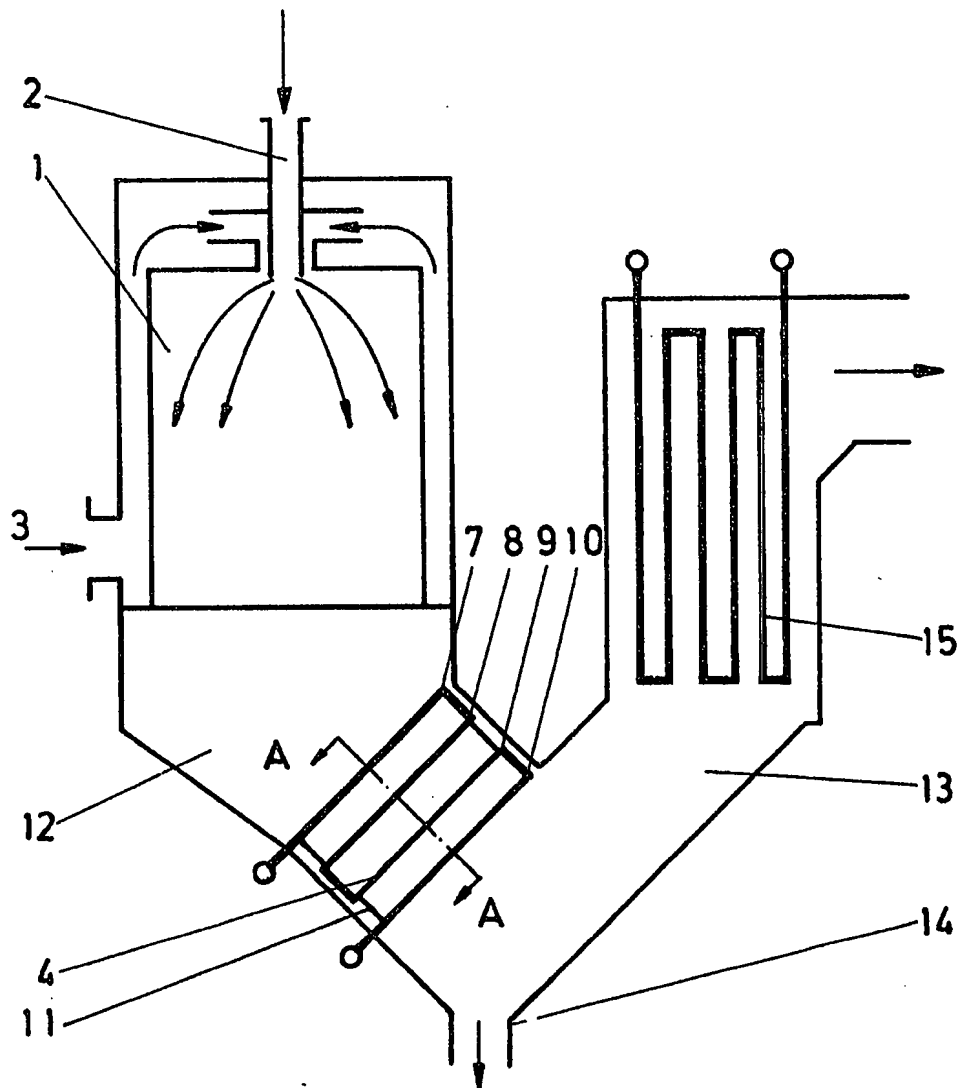


FIG. 1

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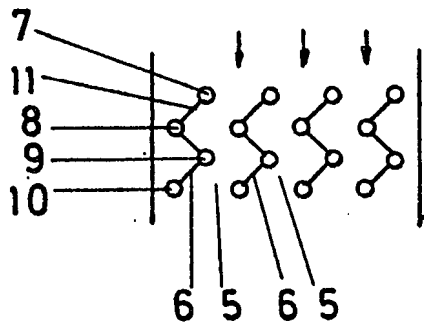


FIG. 2

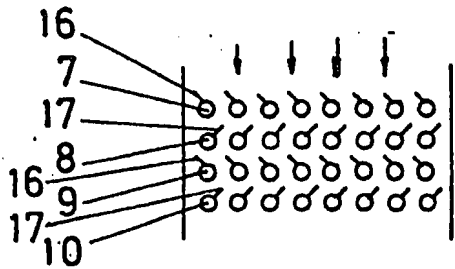


FIG. 3

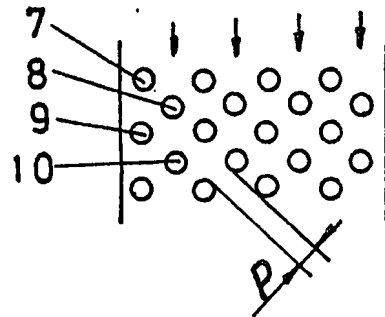


FIG. 4

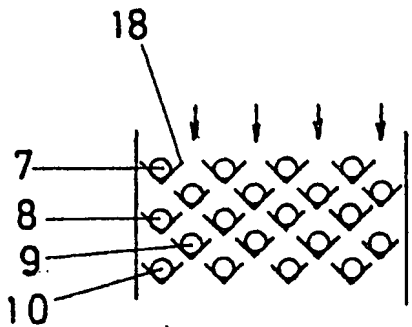


FIG. 5

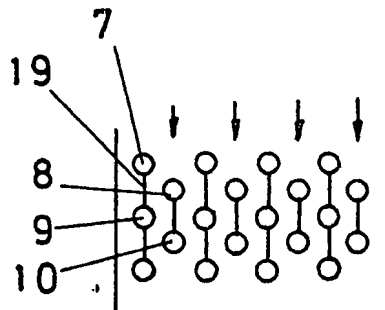


FIG. 6

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